

431.02  
01/30/2003  
Rev. 11

## **ENGINEERING DESIGN FILE**

EDF-ER-327  
Revision 2  
Page 227 of 268

### **Appendix F**

#### **Analysis of Short-Term Risk and ARAR Compliance**

431.02  
01/30/2003  
Rev. 11

**ENGINEERING DESIGN FILE**

EDF-ER-327  
Revision 2  
Page 228 of 268

This page is intentionally left blank.

TECHNICAL MEMORANDUM

CH2MHILL

## ARAR Compliance for Ni-59, Ni-63, and Fe-55 at the ICDF

PREPARED FOR: ICDF OPERATIONS TEAM

PREPARED BY: CH2M HILL

DATE: November 17, 2003

Operations at the INEEL CERCLA Disposal Facility (ICDF) are governed by the applicable or relevant and appropriate requirements (ARARs) identified in the OU 3-13 Record of Decision (ROD). (DOE-ID 1999). As new constituents are identified and evaluated, the relevant ARARs must also be reviewed to identify any compliance issues. This technical memorandum reviews radiological constituents that have been recently identified for disposal at the ICDF that are not included in the current WAC. Table 1 identifies those constituents, and applicable ARARs.

TABLE 1  
Radiological constituents for proposed disposal at ICDF.

Constituent	Relevant ARARs (see TFR-71 Table 3.1.4-1)	New Soil Concentration (pCi/kg) <sup>1</sup>
Ni-59	40 CFR 61.93, DOE O 435.1 DOE O 5400.1	9.50E+06
Ni-63	40 CFR 61.93, DOE O 435.1 DOE O 5400.1	6.00E+07
Fe-55	40 CFR 61.93 DOE O 435.1 DOE O 5400.1	2.00E+09

<sup>1</sup>Soil Concentration provided via e-mail originating from Jim Curnutt on 8/27/03.

## ARAR Requirements for Radionuclides at the ICDF

Compliance with National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations is an ARAR for the ICDF Complex. The dose rates for ICDF operations were calculated in EDF-ER-290, "NESHAP Modeling for the ICDF Complex," using data from the "INEEL CERCLA Disposal Facility Design Inventory" (EDF-ER-264). The constituents identified in Table 1 were not included in the original design inventory or the Waste Acceptance Criteria.

Additionally, operations at the ICDF must meet the worker protection requirements of DOE Order 435.1, and the public exposure requirements of DOE Order 5400.1. For a complete

review of all ARARs for the ICDF operations, please see TFR-71, "Technical and Functional Requirements: WAG 3 INEEL CERCLA Disposal Facility and Evaporation Pond."

## Necessary Evaluation and Revision for Compliance

### NESHAPs Modeling for the ICDF Complex (EDF-ER-290)

To comply with 40 CFR 61.93, initial screening, modeling, and evaluation must be conducted to estimate radionuclide emissions from the ICDF operations (see 40 CFR Part 61 Appendix D). This process is described in EDF-ER-290. Based on available information, it is not feasible to determine whether disposal of soil contaminated with these radionuclides will be below the level of concern, or that disposal of these isotopes will not exceed the ICDF's operational goal of 1 mrem/yr.

As a result, EDF-ER-290 must be revised. New NESHAPs modeling is required to ensure that the constituents identified in Table 1 will not result in radionuclide activity exceeding the exposure limits required in 40 CFR 61.93.

### Short Term Risk Assessment (EDF-ER-327)

To Be Considered (TBC) ARARs include DOE Orders 435.1 and 5400.1. These Orders require ICDF operations to limit radiological exposure to human receptors. As noted in the Short Term Risk Assessment, the ICDF Complex WAC provides a bounding scenario for human exposure.

## Conclusion

The primary ARAR compliance concern should focus on the potential effects that Ni-59, Ni-63, and Fe-55 may have on NESHAPs and short term risk. Since the radiological studies use the WAC as an important baseline, any revisions to the WAC should not be made without first updating analyses in NESHAPs modeling and risk assessments to ensure ARAR compliance.

Other than NESHAPs and short term risk, addition of these radionuclides will not impact any of the other ARARs. For further information regarding the potential impacts on NESHAPs and short term risk, please see the respective technical memoranda.

## References

DOE-ID, 2002, *ICDF Complex Waste Acceptance Criteria*, DOE/ID-10881, Rev. 0,  
U.S. Department of Energy Idaho Operations Office, March 2002.

DOE-ID, 1999, *Final Record of Decision Idaho Nuclear Technology and Engineering Center, Operable Unit 3-13*, DOE/ID-10660, Rev. 0, U.S. Department of Energy Idaho Operations Office, October 1999.

DOE O 435.1, "Radioactive Waste Management," U.S. Department of Energy, August 28, 2001.

DOE O 5400.5, "Radiation Protection of the Public and the Environment," U.S. Department of Energy, January 7, 1993.

EDF-ER-264, 2001, "INEEL CERCLA Disposal Facility Design Inventory (Title I)," Rev. 0, Environmental Restoration Program, Idaho National Engineering and Environmental Laboratory, Idaho Falls, July 2001.

EDF-ER-290, 2002, "NESHAP Modeling for ICDF Complex," Rev. 1, Environmental Restoration Program, Idaho National Engineering and Environmental Laboratory, May 2002.

EDF-ER-327, 2003, "INEEL CERCLA Disposal Facility Short-Term Risk Assessment" Rev. 0, Environmental Restoration Program, Idaho National Engineering and Environmental Laboratory, February 2003.

TFR-71, 2002, "Technical and Functional Requirements - WAG 3 INEEL CERCLA Disposal Facility and Evaporation Pond," Rev. 2, U.S. Department of Energy Idaho Operations Office, Idaho Falls, Idaho, May 2002.

TECHNICAL MEMORANDUM

CH2MHILL

## Analysis of Ni-59, Ni-63, and Fe-55 Short-term Risk for the ICDF, Revision 1

PREPARED FOR: ICDF Implementation Project

PREPARED BY: CH2M HILL Inc.

DATE: December 2, 2003

The purpose of this technical memorandum is to evaluate the impact on INEEL CERCLA Disposal Facility (ICDF) short-term risk resulting from the addition of Nickel-59 (Ni-59), Nickel-63 (Ni-63), and Iron-55 (Fe-55) to the ICDF design inventory.

### Requirements

For the given soil concentrations, estimate the short-term risk produced by the radionuclides and evaluate EDF-ER-327<sup>1</sup> to determine cumulative impacts on the short-term risk evaluation.

### Background

The INEEL plans to dispose of remediation wastes at the ICDF. Recent evaluations detected three radionuclides, which had not been included in the original design inventory (EDF-ER-264<sup>2</sup>). As such, these radionuclides were not considered during the short-term risk evaluation conducted as part of the ICDF design. The three radionuclides are Ni-59, Ni-63, and Fe-55.

### Given Data and Assumptions

Table 1 shows the short-term risk input for the three radionuclides.

TABLE 1.  
Input Parameters for Ni-59, Ni-63, and Fe-55.

Constituent	New Soil Concentration (pCi/kg) <sup>1</sup>	Half-Life (yr) <sup>2</sup>	Radiation Emitted
Ni-59	9.50E+06	7.60E+04	β
Ni-63	6.00E+07	1.00E+02	β
Fe-55	2.00E+09	2.70E+00	β

<sup>1</sup> EDF-ER-327, 2003, "INEEL CERCLA Disposal Facility Short-Term Risk Assessment," Rev. 0, Environmental Restoration Program, Idaho National Engineering and Environmental Laboratory, 2003.

<sup>2</sup> EDF-ER-264, 2002, "INEEL CERCLA Disposal Facility Design Inventory," Rev. 1, Environmental Restoration Program, Idaho National Engineering and Environmental Laboratory, 2003.

**TABLE 1.**  
Input Parameters for Ni-59, Ni-63, and Fe-55.

<sup>1</sup>Soil Concentration provided via e-mail originating from Jim Curnutt on 8/27/03.

<sup>2</sup>"Table of Nuclides" (c) 2000-2002 Nuclear Data Evaluation Lab. Korea Atomic Energy Research Institute <http://www2.bnl.gov/ton/index.html>"

## Methodology

This evaluation involves calculating short-term risks for each of the radionuclides listed above in accordance with the methodologies presented in EDF-ER-327. Following this evaluation, consider the overall cumulative impacts to the receptors and determine if modifications to the EDF-ER-327 are required.

## Calculation of Short-term Risk

Similar to EDF-ER-327, this evaluation is conducted based on external and internal radiation exposure. The internal radiation exposure includes both inhalation and ingestion.

### External Radiation Exposure

Ni-59, Ni-63, and Fe-55 are pure beta radiation emitters. As a result, none of the three radionuclides produce gamma radiation that could pose an external risk under the exposure scenarios discussed in EDF-ER-327. All three radionuclides can be screened from further external exposure short-term risk consideration based on Criterion 5 (exclusion of radionuclides that do not produce significant gamma radiation) discussed on page 3-14 of EDF-ER-327. However, consistent with this criterion, such radionuclides will be considered further for the inhalation and ingestion exposure assessments. The ICDF fill materials will shield the beta radiation produced by Ni-59, Ni-63, and Fe-55. As a result, the radionuclides will not contribute to short-term risk from an external exposure standpoint.

### Internal Radiation Exposure

Additional evaluations were performed, however, to determine the extent of the impact of inhalation and ingestion of waste contaminated with these three radionuclides upon the Total Effective Dose Equivalent (TEDE) for twelve different hypothetical receptors: the ICDF Landfill Laborer, the ICDF Landfill Visitor, the Evaporation Pond Operator, the Evaporation Pond Visitor, the Treatment Unit Operator, the Treatment Unit Visitor, the CFA Office Worker, the Delivery Driver, the ICDF Office Worker, the INEEL Worker, the INEEL Visitor (fence line), and the Highway 26 Rest Area Visitor.

Detailed receptor dose rate calculations were completed for the Treatment Unit Operator scenario described in EDF-ER-327, which is this project's bounding internal radiation exposure dose rate scenario. The basis for eliminating the other scenarios described in the short term risk EDF as bounding has been provided below.

For both inhalation and ingestion pathways, the Cumulative Effective Dose Equivalent (CEDE) was calculated using the following equation:

$$CEDE = \left[ \frac{C_i \times U_i \times 2370 \times 5000}{ALI_i} \right]$$

where:

$C_i$  = concentration of the  $i^{\text{th}}$  radionuclide, in  $\mu\text{Ci}/\text{cm}^3$  for inhalation, or  $\mu\text{Ci}/\text{g}$  for ingestion, where:

$\mu\text{Ci}/\text{cm}^3 = \text{Ci}/\text{kg} \times 1\text{E+06} \mu\text{Ci}/\text{Ci} \times 1\text{E-09} \text{ kg}/\mu\text{g} \times 1\text{E-06} \text{ m}^3/\text{cm}^3 \times 40 \mu\text{g}/\text{m}^3$ ,  
and;

$\mu\text{Ci}/\text{g} = \text{Ci}/\text{kg} \times 1\text{E+06} \mu\text{Ci}/\text{Ci} \times 1\text{E-03} \text{ kg}/\text{g}$

$U_j$  = Uptake rate for the  $j^{\text{th}}$  pathway, using:

$1\text{E+07} \text{ cm}^3/\text{d}$  for inhalation, and;

$50 \text{ mg}/\text{d}$  for ingestion

$2,370$  = days of exposure duration

$ALI_i$  = Annual Limit of Intake for the  $i^{\text{th}}$  radionuclide, in  $\mu\text{Ci}$  (see table,  
below), and;

$5,000$  = CEDE per  $ALI_i$ , in mrem/y.

**TABLE 2.**  
Annual Limits of Intake for the Isotopes of Interest<sup>1</sup>

Isotopes	ALI (Inhalation)	ALI (Ingestion)
Ni-59	4E+03	2E+04
Ni-63	2E+03	9E+03
Fe-55	2E+03	9E+03

<sup>1</sup> In choosing the appropriate ALIs for each isotope, the most conservative value was chosen, independent of lung retention factors (e.g., "D" or "W"). Source of ALI values: [www.nrc.gov/reading-rm/doc-collections/cfr/part020/appb/iron-55.html](http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/appb/iron-55.html).

## Results

### Landfill Laborer

The contribution to the inhalation and ingestion dose rates are presented in Table 3, including the percentage of total dose from a cumulative constituent perspective.

**TABLE 3.**  
Landfill Laborer Dose Rates.

Isotope	Inhalation Dose Rate (mrem/yr)	Ingestion Dose Rate (mrem/yr)	Total Dose Rate (mrem/yr)	Percent Of Maximum Total Dose Rate <sup>1</sup>
Ni-59	1.1E-02	2.8E-01	2.9E-01	1.9E-03
Ni-63	1.4E-01	4.0E+00	4.1E+00	2.7E-02
Fe-55	4.7E+00	1.3E+02	1.3E+02	8.7E-01
<b>ADDITIONAL TOTAL DOSE RATE DUE TO ADDED CONTAMINANTS:</b>			1.3E+02	8.9E-01

<sup>1</sup> The "Maximum Total Dose Rate" is listed in Table 2-1 of the EDF as 1.5E+01 rem/yr.

The detailed calculations used to derive the values tabled above are presented in Appendix A.

### Other Scenarios, A Bounding Scenario Discussion

The Landfill Visitor scenario differs from the Landfill Laborer scenario discussed above, only in the length of the receptor's exposure duration. The duration of the laborer's exposure period, used for these calculations, was 2,370 days. The duration of the Landfill Visitor's exposure was only three days over the life of the project. Therefore, the dose resulting from the Landfill Laborer's scenario is considered bounding, relative to the dose received by the Landfill Visitor. Qualitative comparisons have been made to the bounding Landfill Laborer scenario for each of the remaining eleven scenarios, and the results are presented in Table 4, below.

**TABLE 4.**  
Determination of Bounding Nature for All Relevant Scenarios.

Receptor(s)	Limiting Parameter(s) (Relative to Bounding Scenario)	Bounding?	Reason For Bounding / Not Bounding <sup>1</sup>
Landfill Laborer, Landfill Bulldozer Operator, Landfill Truck Driver	N/A	Yes	Longest exposure duration (2,370 days)  Shortest distance between source and receptors
Evaporation Pond Operator	Source term, exposure duration	No	Source term does not contain the full complement of radionuclides found in the landfill.  Exposure duration of 10,000 hrs total, vs. 23,700 hrs (2,370 days) for Landfill Laborer.
Evaporation Pond Visitor	Exposure duration	No	Exposure duration of 3 days vs. 2,370 days.
Treatment Unit Operator	Exposure duration	No	Radiation doses resulting from inhalation and ingestion were not considered in accordance with Section 4.4 of EDF-ER-327.
ICDF Office Worker	Distance from source	No	Minimum distance of 100 m from source vs. direct contact or < 10 m for laborer.
CFA Office Worker	Distance from source	No	Minimum distance of 4,000 m from source vs. direct contact or < 10 m for laborer.
Delivery Driver	Distance from source, exposure duration	No	Minimum distance of 100 m from source vs. direct contact or < 10 m for laborer.  Maximum exposure duration of 3,000 hrs vs 23,700 hrs for Landfill Laborer.
INEEL Worker	Exposure duration	No	Exposure duration of 1,200 hrs vs. 23,700 hrs for Landfill Laborer
INEEL Visitor	Exposure duration, distance from source	No	10 Exposure duration of 1,200 hrs vs. 23,700 hrs for Landfill Laborer  85 m from complex vs. direct contact
ICDF Visitor	Exposure duration	No	Exposure duration of 360 hrs vs. 23,700 hrs for Landfill Laborer
Highway 26 Rest Area Visitor	Distance from source	No	Minimum distance of 4000 m from source vs. direct contact or < 10 m for Landfill Laborer.

**TABLE 4.**  
Determination of Bounding Nature for All Relevant Scenarios.

Receptor(s)	Limiting Parameter(s) (Relative to Bounding Scenario)	Bounding?	Reason For Bounding / Not Bounding <sup>1</sup>
-------------	---	-----------	--

<sup>1</sup> See EDF-ER-327 for bounding scenario data.

## **Conclusions**

Based upon the results listed in Table 3, the addition of Ni-59, Ni-63, and Fe-55 to the source term results in an insignificant (less than 1%) increase in worker dose rates and can be eliminated from further consideration under the short-term risk scenarios. Consistent with Criterion 6 (page 3-14 of EDF-ER-327), those radionuclides that contribute less than 1% of the total dose may be eliminated from further consideration. As such, it is recommended that no additional modifications be made to EDF-ER-327 .

431.02  
01/30/2003  
Rev. 11

## **ENGINEERING DESIGN FILE**

EDF-ER-327  
Revision 2  
Page 238 of 268

### **APPENDIX A**

#### **CALCULATION BRIEF**

**DETERMINATION OF DOSE RATE CONTRIBUTION FROM ADDITION OF Ni-59, Ni-63  
AND Fe-55 AT THE ICDF**

**NICKEL-59 - INHALATION CEDE**

$$9.5 \text{ E+06 pCi/kg} = 9.5\text{E-06 Ci/kg}$$

$$\begin{aligned}\mu\text{Ci}/\text{cm}^3 &= \text{Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-09 kg}/\mu\text{g} \times 1\text{E-06 m}^3/\text{cm}^3 \times 40 \mu\text{g/m}^3 \\ &= 9.5\text{E-06 Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-09 kg}/\mu\text{g} \times 1\text{E-06 m}^3/\text{cm}^3 \times 40 \mu\text{g/m}^3 \\ &= 3.8\text{E-13 } \mu\text{Ci/cm}^3\end{aligned}$$

$$CEDE = \left[ \frac{C_i \times U_i \times 2370 \times 5000}{ALI_i} \right]$$

$$CEDE = \left[ \frac{3.8E-13 \mu\text{Ci}/\text{cm}^3 \times 1E7 \text{cm}^3/d \times 2370d \times 5000 \text{mrem/yr}}{4E+03 \mu\text{Ci}} \right]$$

$$CEDE = 1.1E-02 \text{ mrem/yr}$$

**NICKEL-59 - INGESTION CEDE**

$$\mu\text{Ci/g} = \text{Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-03 kg/g}$$

$$\begin{aligned}&= 9.5\text{E-06 Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-03 kg/g} \\ &= 9.5\text{E-3 } \mu\text{Ci/g}\end{aligned}$$

$$CEDE = \left[ \frac{C_i \times U_i \times 2370 \times 5000}{ALI_i} \right]$$

$$CEDE = \left[ \frac{9.5E-3 \mu\text{Ci/g} \times 50 \text{mg/d} \times 1E-03 \text{kg/g} \times 2370 \text{d} \times 5000 \text{mrem/yr}}{2E+04 \mu\text{Ci}} \right]$$

$$CEDE = 2.8E-01 \text{ mrem/yr}$$

**NICKEL-63 - INHALATION CEDE**

$$6.0 \text{ E+07 } \mu\text{Ci/kg} = 6.0 \text{ E-05 Ci/kg}$$

$$\mu\text{Ci}/\text{cm}^3 = \text{Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-09 kg}/\mu\text{g} \times 1\text{E-06 m}^3/\text{cm}^3 \times 40 \mu\text{g/m}^3$$

$$= 6.0 \text{ E-05 Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-09 kg}/\mu\text{g} \times 1\text{E-06 m}^3/\text{cm}^3 \times 40 \mu\text{g/m}^3$$

$$= 2.4 \text{ E-12 } \mu\text{Ci/cm}^3$$

$$CEDE = \left[ \frac{C_i \times U_i \times 2370 \times 5000}{ALI_i} \right]$$

$$CEDE = \left[ \frac{2.4 \text{ E-12 } \mu\text{Ci/cm}^3 \times 1\text{E7 cm}^3 / d \times 2370d \times 5000 \text{ mrem/yr}}{2 \text{ E+03 } \mu\text{Ci}} \right]$$

$$CEDE = 1.4 \text{ E-01 mrem/yr}$$

**NICKEL-63 - INGESTION CEDE**

$$\mu\text{Ci/g} = \text{Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-03 kg/g}$$

$$= 6.0 \text{ E-05 Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-03 kg/g}$$

$$= 6.0 \text{ E-2 } \mu\text{Ci/g}$$

$$CEDE = \left[ \frac{C_i \times U_i \times 2370 \times 5000}{ALI_i} \right]$$

$$CEDE = \left[ \frac{6.0 \text{ E-2 } \mu\text{Ci/g} \times 50 \text{ mg/d} \times 1\text{E-03 kg/g} \times 2370d \times 5000 \text{ mrem/yr}}{9 \text{ E+03 } \mu\text{Ci}} \right]$$

$$CEDE = 3.9 \text{ E+00 mrem/yr}$$

**IRON-55 - INHALATION CEDE**

$$6.0 \text{ E+07 } \mu\text{Ci/kg} = 6.0 \text{ E-05 Ci/kg}$$

$$\mu\text{Ci}/\text{cm}^3 = \text{Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-09 kg}/\mu\text{g} \times 1\text{E-06 m}^3/\text{cm}^3 \times 40 \mu\text{g/m}^3$$

$$= 2.0 \text{ E-03 Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-09 kg}/\mu\text{g} \times 1\text{E-06 m}^3/\text{cm}^3 \times 40 \mu\text{g/m}^3$$

$$= 8.0 \text{ E-11 } \mu\text{Ci/cm}^3$$

$$CEDE = \left[ \frac{C_i \times U_i \times 2370 \times 5000}{ALI_i} \right]$$

$$CEDE = \left[ \frac{8.0E-11 \mu\text{Ci/cm}^3 \times 1E7 \text{ cm}^3/d \times 2370d \times 5000 \text{ mrem/yr}}{2E+03 \mu\text{Ci}} \right]$$

$$CEDE = 4.7E+00 \text{ mrem/yr}$$

**IRON-55 INGESTION CEDE**

$$\mu\text{Ci/g} = \text{Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-03 kg/g}$$

$$= 2.0 \text{ E-03 Ci/kg} \times 1\text{E+06 } \mu\text{Ci/Ci} \times 1\text{E-03 kg/g}$$

$$= 2.0 \text{ E+00 } \mu\text{Ci/g}$$

$$CEDE = \left[ \frac{C_i \times U_i \times 2370 \times 5000}{ALI_i} \right]$$

$$CEDE = \left[ \frac{2.0E+00 \mu\text{Ci/g} \times 50 \text{ mg/d} \times 1E-03 \text{ kg/g} \times 2370d \times 5000 \text{ mrem/yr}}{9E+03 \mu\text{Ci}} \right]$$

$$CEDE = 1.3E+02 \text{ mrem/yr}$$

TECHNICAL MEMORANDUM

CH2MHILL

## Analysis of U-233 Short-term Risk for the ICDF

PREPARED FOR: ICDF Implementation Project  
PREPARED BY: CH2M HILL Inc.  
DATE: March 24, 2004

The purpose of this technical memorandum is to evaluate the impact on INEEL CERCLA Disposal Facility (ICDF) short-term risk resulting from the new concentration level of Uranium-233 (U-233).

### Requirements

For the given soil concentrations, estimate the short-term risk produced by the radionuclide (U-233) and evaluate EDF-ER-327<sup>1</sup> to determine cumulative impacts on the short-term risk evaluation.

### Background

The INEEL plans to dispose of remediation wastes at the ICDF. Recent evaluations detected a new concentration of U-233, which is greater than that of the original design inventory (EDF-ER-264<sup>2</sup>).

### Given Data and Assumptions

Table 1 shows the short-term risk input.

TABLE 1.  
Input Parameters for U-233.

Constituent	New Soil Concentration (pCi/kg) <sup>1</sup>	Half-Life (yr) <sup>2</sup>	Radiation Emitted
U-233	1.64E+05	1.59E+05	$\alpha, \beta, \gamma$

<sup>1</sup> Based on concentrations provided by BBWI in CN-23 dated February 3, 2004.

<sup>2</sup> "Table of Nuclides" (c) 2000-2002 Nuclear Data Evaluation Lab. Korea Atomic Energy Research Institute <http://www2.bnl.gov/ton/index.html>"

---

<sup>1</sup> EDF-ER-327, 2003, "INEEL CERCLA Disposal Facility Short-Term Risk Assessment," Rev. 0, Environmental Restoration Program, Idaho National Engineering and Environmental Laboratory, 2003.

<sup>2</sup> EDF-ER-264, 2002, "INEEL CERCLA Disposal Facility Design Inventory," Rev. 1, Environmental Restoration Program, Idaho National Engineering and Environmental Laboratory, 2003.